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NATIONAL DAM SAFETY PROGRAM. RAINEY LAKE DAM (MO 20267), VERDIG--ETC(U)
AUG 80 J HEALY, S BRADY, N MORALES DACW43-80-C-0073
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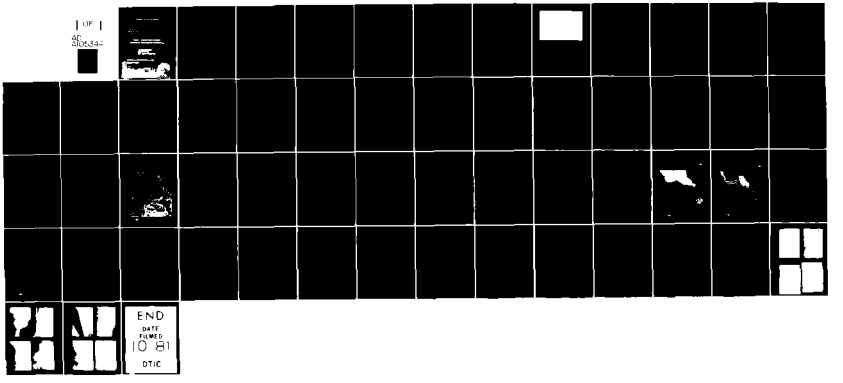

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REPORT DOCUMENTATION PAGE	READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER	2. GOVT ACCESSION NO. AD-A105 344	3. RECIPIENT'S CATALOG NUMBER
4. TITLE *(and Subtitle)* Phase I Dam Inspection Report National Dam Safety Program Rainey Lake Dam (MO 20267) Jasper County, Missouri	5. TYPE OF REPORT & PERIOD COVERED Final Report.
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Anderson Engineering, Inc.	8. CONTRACT OR GRANT NUMBER(s) DACW43-80-C-0073
9. PERFORMING ORGANIZATION NAME AND ADDRESS U.S. Army Engineer District, St. Louis Dam Inventory and Inspection Section, LMSED-PD 210 Tucker Blvd., North, St. Louis, Mo. 63101	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS U.S. Army Engineer District, St. Louis Dam Inventory and Inspection Section, LMSED-PD 210 Tucker Blvd., North, St. Louis, Mo. 63101	12. REPORT DATE August 1980
	13. NUMBER OF PAGES Approximately 40
14. MONITORING AGENCY NAME & ADDRESS *(if different from Controlling Office)* National Dam Safety Program. Rainey Lake Dam (MO 20267), Verdigris-Neosho River Basin, Jasper County, Missouri. Phase I Inspection Report.	15. SECURITY CLASS. *(of this report)* UNCLASSIFIED
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
16. DISTRIBUTION STATEMENT *(of this Report)* Approved for release; distribution unlimited.	
17. DISTRIBUTION STATEMENT *(of the abstract entered in Block 20, if different from Report)*	
18. SUPPLEMENTARY NOTES	
19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)* Dam Safety, Lake, Dam Inspection, Private Dams	
20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)* This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.	

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DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT CORPS OF ENGINEERS
210 TUCKER BOULEVARD, NORTH
ST. LOUIS, MISSOURI 63101

REPLY TO ATTENTION OF

SUBJECT: Phase I Inspection Report
Rainey Lake Dam
Missouri No. 20267

This report presents the results of field inspection and evaluation of the Rainey Lake Dam.

It was prepared under the National Program of Inspection of Non-Federal Dams.

This dam has been classified as unsafe, emergency by the St. Louis District as a result of the application of the following criteria:

a. Spillway will not pass a 10-year frequency flood without overtopping of the dam. The spillway is, therefore, considered to be unusually small and seriously inadequate.

b. Overtopping could result in dam failure.

c. Dam failure significantly increases the hazard to life and property downstream.

SUBMITTED BY: SIGNED
Chief, Engineering Division
11 SEP 1980
Date

APPROVED BY: SIGNED
Colonel, CE, District Engineer
11 SEP 1980
Date

A

VERDIGRIS - NEOSHO RIVER BASIN

RAINEY LAKE DAM
JASPER COUNTY, MISSOURI
MISSOURI INVENTORY NO. 20267

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

Prepared By

Anderson Engineering, Inc., Springfield, Missouri
Hanson Engineers, Inc., Springfield, Illinois

Under Direction Of

St. Louis District, Corps of Engineers

For

Governor of Missouri

JULY, 1980

PHASE I REPORT
NATIONAL DAM SAFETY PROGRAM
SUMMARY

Name of Dam: Rainey Lake Dam
State Located: Missouri
County Located: Jasper
Stream. Tributary of Short Creek
Date of Inspection: May 29, 1980

Rainey Lake Dam was inspected by an interdisciplinary team of engineers from Anderson Engineering, Inc. of Springfield, Missouri, and Hanson Engineers, Inc. of Springfield, Illinois. The purpose of this inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and visual inspection, in order to determine if the dam poses hazards to human life or property.

The guidelines used in the assessment were furnished by the Department of the Army, Office of the Chief of Engineers, and they have been developed with the help of several Federal and State agencies, professional engineering organizations, and private engineers. Based on these guidelines, the St. Louis District, Corps of Engineers has determined that this dam is in the high hazard potential classification, which means that loss of life and appreciable property loss could occur if the dam fails. The estimated damage zone extends approximately five miles downstream of the dam. Located within this zone are three dwellings, a tailings pond, a chemical plant, water tanks, and two buildings.

The dam is in the small size classification, since the maximum storage capacity is greater than 50 ac-ft but less than 1,000 ac-ft.

Our inspection and evaluation indicates that the combined spillways do not meet the criteria set forth in the guidelines for a dam having the above size and hazard potential. The combined spillways will pass 12 percent of the Probable Maximum Flood without overtopping. The Probable Maximum Flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The guidelines require that a dam of small size with a high downstream hazard potential pass 50 to 100 percent of the PMF. Considering the height of dam (14 ft), the maximum storage capacity (101 ac-ft), and U. S. Highway 66 embankment immediately downstream of the lake, 100 percent of the PMF has been determined to be the

appropriate spillway design flood. The 10 percent probability flood will overtop the dam. The 10 percent probability flood is one that has a 10 percent chance of being exceeded in any given year.

Deficiencies visually observed by the inspection team were: (1) Erosional areas on the upstream embankment face at Station 13 + 00; (2) erosional area on the downstream toe at the curve of the embankment near Station 8 + 00; (3) numerous trees (4 to 24 in. diameter) on the embankment slopes; (4) animals burrows on the upstream slope between Station 9 + 00 and 13 + 00; and (5) erosion under the concrete spillway.

Another deficiency was the lack of seepage and stability analysis records.

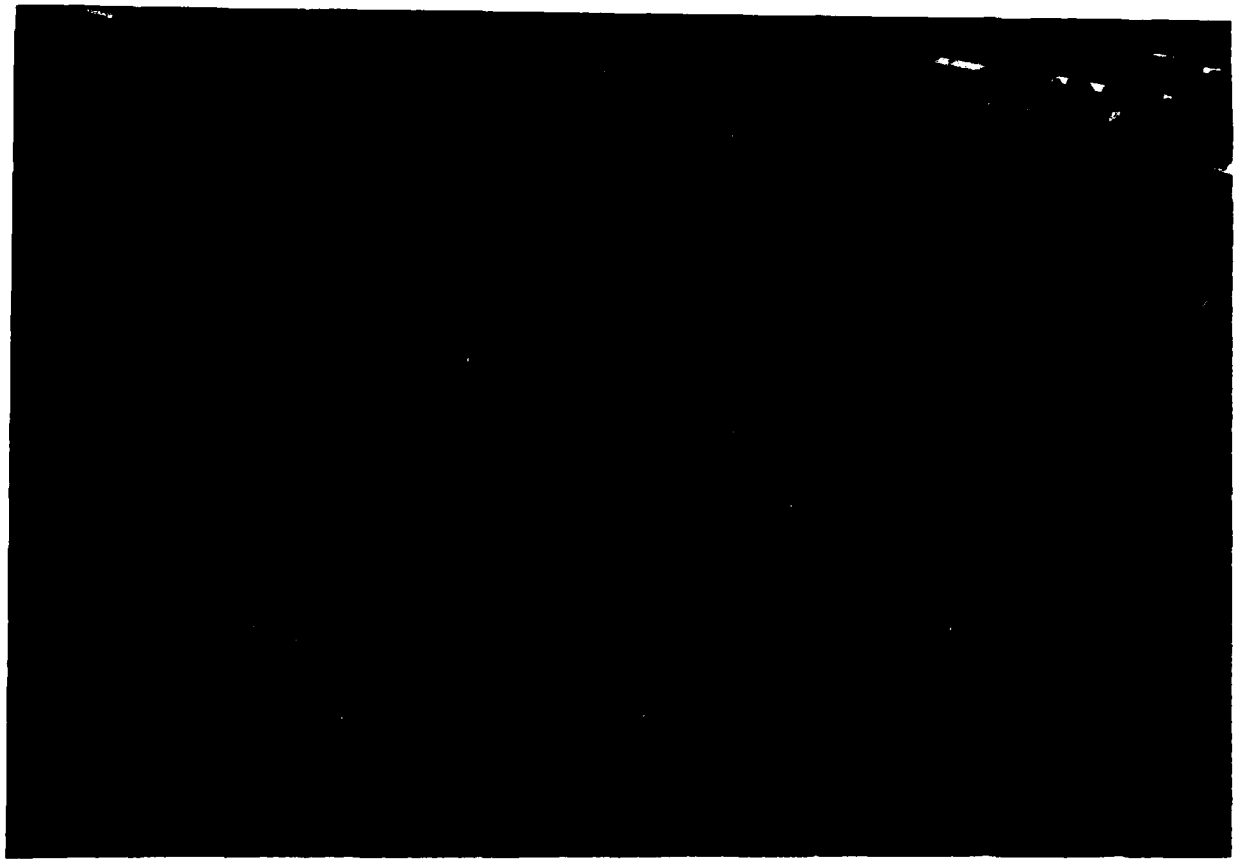
It is recommended that the owners take the necessary action without delay to correct the deficiencies reported herein. A detailed discussion of these deficiencies is included in the following report.

Jack Healy, P.E.
Hanson Engineers, Inc.

Steve Brady, P.E.
Anderson Engineering, Inc.

Nelson Morales, P.E.
Hanson Engineers, Inc.

Tom Beckley, P.E.
Anderson Engineering, Inc.



AERIAL VIEW OF LAKE AND DAM

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
RAINEY LAKE DAM ID NO. 20267

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APPENDICES

SECTION 1 - PROJECT INFORMATION

1.1 GENERAL:

A. Authority:

The National Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of safety inspection of dams throughout the United States. Pursuant to the above, the St. Louis District, Corps of Engineers, District Engineer directed that a safety inspection be made of Rainey Lake Dam in Jasper County, Missouri.

B. Purpose of Inspection:

The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and a visual inspection in order to determine if the dam poses hazards to human life or property.

C. Evaluation Criteria.

Criteria used to evaluate the dam were furnished by the Department of the Army, Office of the Chief of Engineers, "Recommended Guidelines for Safety Inspection of Dams, Appendix D." These guidelines were developed with the help of several federal agencies and many state agencies, professional engineering organizations, and private engineers.

1.2 DESCRIPTION OF PROJECT:

A. Description of Dam and Appurtenances:

Rainey Lake Dam is an earth fill structure approximately 14 ft high and 1,675 ft long at the crest. The appurtenant works consist of an uncontrolled concrete lined spillway section at Station 2 + 50 and an uncontrolled emergency spillway at the south abutment.

Sheet 3 of Appendix A shows a plan, profile, and typical section of the embankments.

B. Location:

The dam is located in the Southwestern part of Jasper County, Missouri, on a tributary of Short Creek. The dam and lake are within the Joplin West, Missouri, 7.5 minute quadrangle sheet (Section 12, T27N, R34W - latitude 38°05.1'; longitude 94°35.4'). Sheet 2 of Appendix A shows the general vicinity.

C. Size Classification:

With an embankment height of 14 ft and a maximum storage capacity of approximately 101 acre-ft, the dam is in the small size category.

D. Hazard Classification.

The St. Louis District, Corps of Engineers has classified this dam as a high hazard dam. The estimated damage zone extends approximately five miles downstream of the dam. Located within this zone are three dwellings, a tailings pond, a chemical plant, water tanks and two buildings. Location of affected features within the damage zone were verified by the inspection team.

E. Ownership.

The dam is owned by Landreth Realty Company, Attn. Mr. Bill Rainey. The owner's address is 303 East 4th Street, Joplin, Missouri.

F. Purpose of Dam:

The dam was constructed primarily for recreation.

G. Design and Construction History.

The dam was constructed in 1951 and 1952 with Mr. Rainey, the owner, as the general contractor. No design or plans for the dam were available.

Mr. Rainey stated that the concrete spillway was designed by Mr. Guy Greenwall. No additional design was done for the dam.

A small pond had been constructed in the lake bed area a number of years before. This pond was located over a mine shaft approximately 20 ft deep. The pond was drained prior to construction of the existing lake.

The embankment was formed from the material obtained from the lake bed. According to Mr. Rainey, a core trench was not installed. The embankment was constructed after the base area of the dam was scarified.

The earthwork was moved and compacted by use of a dozer. There is no internal drainage or particular zoning of the embankment.

No modifications to the dam have been reported since the initial construction.

H. Normal Operating Procedures.

All flows will be passed by the uncontrolled concrete spillway and the emergency spillway. Information from Mr. Clarence Coburn, caretaker, indicates that the dam has been overtopped once with an overtopping depth of about 1 ft.

1.3 PERTINENT DATA:

Pertinent data about the dam, appurtenant works, and reservoir are presented in the following paragraphs. Sheet 3 of Appendix A presents a plan, profile, and typical section of the embankment.

A. Drainage Area:

The drainage area for this dam, as obtained from the U.S.G.S. quad sheet, is approximately 2,138 acres.

B. Discharge at Dam Site:

(1) All discharge at the dam site is through uncontrolled spillways.

(2) Estimated Total Spillway Capacity at Maximum Pool (Top of Dam - El. 956.3): 2,020 cfs

(3) Estimated Capacity of Principal Spillway: 520 cfs

(4) Estimated Experience Maximum Flood at Dam Site: 4,800 cfs at Elevation 957.3

(5) Diversion Tunnel Low Pool Outlet at Pool Elevation: Not Applicable

(6) Diversion Tunnel Outlet at Pool Elevation. Not Applicable

(7) Gated Spillway Capacity at Pool Elevation: Not Applicable

(8) Gated Spillway Capacity at Maximum Pool Elevation: Not Applicable

C. Elevations:

All elevations are consistent with an assumed mean sea level elevation of 953.0 for the principal spillway crest (estimated from quadrangle map).

(1) Top of Dam: 956.3 ft, MSL

(2) Principal Spillway Crest. 953.0 ft, MSL

(3) Emergency Spillway Crest: 954.0 ft, MSL

(4) Principal Outlet Pipe Invert: Not Applicable

(5) Streambed at Centerline of Dam. 943.0 ft, MSL

(6) Pool on Date of Inspection: 953.1 ft, MSL

(7) Apparent High Water Mark: Unknown

(8) Maximum Tailwater: Not Applicable

(9) Upstream Portal Invert Diversion Tunnel: Not Applicable

(10) Downstream Portal Invert Diversion Tunnel. Not Applicable

D. Reservoir Lengths.

(1) At Top of Dam: 2,500 ft

(2) At Principal Spillway Crest: 2,000 ft

(3) At Emergency Spillway Crest: 2,150 ft

E. Storage Capacities:

(1) At Principal Spillway Crest. 50 ac-ft

(2) At Top of Dam. 101 ac-ft

(3) At Emergency Spillway Crest: 63 ac-ft

F. Reservoir Surface Areas:

(1) At Principal Spillway Crest: 12 acres

(2) At Top of Dam. 19 acres

(3) At Emergency Spillway Crest: 14 acres

G. Dam:

(1) Type: Rolled Earth

(2) Length at Crest: 1,675 ft

(3) Height: 14 ft

(4) Top Width: 18 ft

(5) Side Slopes: Upstream 1V:4H; Downstream 1V:6H and 1V:3.8H

(6) Zoning. Apparently Homogeneous

(7) Impervious Core. None

(8) Cutoff: None

(9) Grout Curtain: None

H. Diversion and Regulating Tunnel.

(1) Type: Not Applicable

(2) Length: Not Applicable

(3) Closure: Not Applicable

(4) Access. Not Applicable

(5) Regulating Facilities: Not Applicable

I. Spillway:

I.1 Principal Spillway:

(1) Location: Station 2 + 50 (near west abutment)

(2) Type: Concrete slab (trapezoidal section)

I.2 Emergency Spillway:

(1) Location: South Abutment

(2) Type: Earth Cut Channel

J. Regulating Outlets:

There are no regulating facilities associated with this dam.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN:

No design computations or reports for this dam are available. Mr. Rainey stated that Mr. Guy Greenwall designed the concrete primary spillway. No documentation of construction inspection records are known to exist. To our knowledge, there are no documented maintenance data.

A. Surveys:

No information regarding a pre-construction survey was obtainable. The crest of the concrete spillway inlet was used as the site datum for our survey.

B. Geology and Subsurface Materials:

The site is located in the Western Plains geologic region of Missouri. This area is characterized by rolling to hilly topography with oak and hickory forest areas. The sedimentary rock layers exposed in the Ozarks region dip downward away from the Ozarks region, and the higher and younger sedimentary deposits become the surface ledges in southwest Missouri. The soils in this area are residual from the Warsaw formation of the Meramecian Series of the Mississippian System. The Warsaw formation is composed of fine to coarse crystalline, fossiliferous limestone. This formation is the source of "Carthage Marble," an ornamental building stone.

Shallow auger probes into the embankment showed the soils to be dark brown clayey silts which would fall into the Unified Soils group of CL-ML. The soils are believed to be of the Gerald-Craig-Eldon and Baxtor-Newtonia soil association. No chert fragments were noted in the soil. These soils are dark colored prairie soils which have formed on nearly level areas with loess contributing to the soil forming material.

The "Geologic Map of Missouri" indicates a fault approximately 5 miles south of the site. The Missouri Geological Survey has indicated that faults in this area are considered to be inactive and have been for several million years. The publication "Caves of Missouri" indicates there are two caves in Jasper County: Crystal Cave, which is located in Joplin, Missouri; and Ku Klux Cave, which is located in N 1/2, Section 26, T-28-N, R-34-W.

C. Foundation and Embankment Design.

No design computations are available. Seepage and stability analyses were apparently not performed as required in the guidelines. There is apparently no particular zoning of the embankment, and no internal drainage features are known to exist.

D. Hydrology and Hydraulics:

No hydrologic or hydraulic design computations for this dam were available. Based on a field check of spillway dimensions and embankment elevations, and a check of the drainage area on U.S.G.S. quad sheets, hydrologic analyses using U. S. Army Corps of Engineers' guidelines were performed and appear in Appendix C, Sheets 1 through 10.

E. Structure:

The only structure associated with Rainey Lake Dam is the trapezoidal concrete spillway. No design calculations or plans were available. Mr. Rainey stated that Mr. Guy Greenwall designed the concrete spillway.

2.2 CONSTRUCTION.

No construction inspection data have been obtained.

2.3 OPERATION:

Normal flows are passed by the primary concrete spillway section and the earth cut emergency spillway channel. No operating facilities exist.

2.4 EVALUATION:

A. Availability:

No engineering data, seepage or stability analyses, or construction test data were available.

B. Adequacy:

The engineering data available were inadequate to make a detailed assessment of the design, construction, and operation of this structure. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency. These seepage and stability analyses should be performed for appropriate loading conditions (including earthquake loads) and made a matter of record.

C. Validity:

To our knowledge, no valid engineering data on the design or construction of the embankment are available.

SECTION 3 - VISUAL INSPECTON

3.1 FINDINGS.

A. General:

The field inspection was made on May 29, 1980. The inspection team consisted of personnel from Anderson Engineering, Inc. of Springfield, Missouri, and Hanson Engineers, Inc. of Springfield, Illinois. The team members were:

Jack Healy, Hanson Engineers, Inc., (Geotechnical Engineer)
Steve Brady, Anderson Engineering, Inc., (Civil Engineer)
Nelson Morales, Hanson Engineers, Inc., (Hydraulic Engineer)
Tom Beckley, Anderson Engineering, Inc., (Civil Engineer).

Photographs of the dam, appurtenant structures, reservoir, and downstream features are presented in Appendix D.

B. Dam:

The dam embankment appears to be generally in less than satisfactory condition. No sloughing of the embankment was noted. The horizontal and vertical alignments of the crest appeared good, and no surface cracking or unusual movements were obvious. The crest of the embankment was 18 ft wide, and the low point crest elevation was 956.3. The crest of the embankment had an upward slope from the concrete spillway channel to a maximum elevation of 958.7 near the emergency spillway. The horizontal alignment of the embankment was basically L-shaped. The embankment to the north of the lake was approximately 750 ft in length, and to the east of the lake the embankment was approximately 925 ft in length.

The upstream face of the embankment has a slope of 4H:1V from the crest to the water surface. Minor erosion of the slope was observed at Station 13 + 00. Numerous animal burrows were present from about Station 10 + 00 to Station 14 + 00. Trees ranging in diameter of 4 in. to 24 in. were observed. The trees were primarily at the shoreline and extended the full length of the embankment.

The crest and the downstream slope of the embankment had a good grass cover. The slope of the downstream face varies from 6H:1V to 4H:1V. An erosional area was observed at the toe of the slope near Station 8 + 00. No apparent seepage was observed on the downstream slope or at the toe of the embankment.

Shallow auger probes into the embankment indicate the dam to consist of a dark brown clayey silt (CL-ML).

No instrumentation (monuments, piezometers, etc.), was observed.

C. Appurtenant Structures.

C.1 Principal Spillway:

The principal spillway is a concrete lined trapezoidal section. Some minor cracking and spalling of the concrete was observed. Severe erosion under the slab near the outlet was noted. The erosion was starting to extend beyond the spillway along the toe of the embankment slope. The inlet and outlet to the channel were generally clear. Immediately downstream of the spillway, sections of 8 ft high steel swing gates were installed. The purpose of the gates was to allow the trash and debris to be carried under the gate as the gate swings up due to the flow. About 120 ft beyond the swing gates the channel is restricted by the three 9 x 12 ft box culvert cells constructed in the embankment of U. S. Highway 66.

C.2 Emergency Spillway:

The emergency spillway is an earth cut channel near the south abutment. The section during normal rainfall is an ingress channel for runoff from a portion of the watershed. During periods of heavy runoff, it functions as an emergency spillway. The spillway section is generally grass covered. The downstream channel for the emergency spillway parallels and is adjacent to the downstream toe of the embankment. Some riprap was observed at the curve of the embankment (Station 8 + 00) at the toe. Some erosion at the embankment toe was noted in this area. The emergency spillway outlet and the primary outlet converge about 20 ft beyond the concrete spillway slab.

D. Reservoir:

The watershed is generally grass and tree covered pasture-land. Approximately 15 per cent of the watershed is developed commercial and residential areas. The slopes of the watershed are gentle. No slouging or serious erosion was noted. A concrete roadway slab and small concrete dam were observed at the upper end of the reservoir. (See Photograph #1).

E. Downstream Channel:

The downstream channel beyond the box culvert under U. S. Highway 66 is generally grass and tree covered with gentle side slopes.

3.2 EVALUATION:

The tress and undesirable vegetation growth on the dam can provide shelter for small animals and encourage burrowing. Additionally, the trees are potential seepage hazards. The erosional areas on the embankment could worsen and affect the stability

of the embankment. Due to the emergency spillway outlet channel being adjacent to the embankment, serious erosion could result. If unchecked, the erosion beneath the concrete spillway slab could lead to loss of structural stability of the concrete spillway.

Photographs of the dam, appurtenant structures, and the reservoir are presented in Appendix D.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES:

There are no operating facilities associated with this dam. The pool is normally controlled by rainfall, runoff, evaporation, and the capacity of the uncontrolled spillways.

4.2 MAINTENANCE OF DAM:

There is no maintenance program for this dam.

4.3 MAINTENANCE OF OPERATING FACILITIES:

There are no operating facilities for this dam.

4.4 DESCRIPTION OF ANY WARNING SYSTEM IN EFFECT:

The inspection team is unaware of any existing warning system for this dam.

4.5 EVALUATION:

The trees and brush on the dam are potential seepage hazards and encourage animal burrowing. The animal burrows are also potential seepage hazards. The erosional areas at the primary spillway, the upstream and downstream slopes, and at the toe could worsen and affect the stability of the embankment. All of these items are deficiencies which should be corrected. Remedial measures will be required and should be investigated by an engineer experienced in the design and construction of dams. Subsequently, these areas should be inspected periodically to detect any further erosion or seepage.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES.

A. Design Data:

No hydrologic or hydraulic design computations for this dam were available.

B. Experience Data:

No recorded rainfall, runoff, discharge, or reservoir stage data were available for this lake and watershed.

C. Visual Observations:

The approach channel is clear. The emergency spillway, being adjacent to the embankment toe, could, through the spillway's releases, result in serious erosion. The point of convergence of the principal and emergency spillway channels is a potential erosioned area.

D. Overtopping Potential:

The hydraulic and hydrologic analyses (using the U. S. Army Corps of Engineers guidelines and the HEC-1 computer program) were based on: (1) a field survey of spillway dimensions and embankment elevations; and (2) an estimate of the reservoir storage and the pool and drainage areas from the Joplin-West Missouri-Kansas, 7.5 Minute U.S.G.S. quad sheets.

Based on the hydrologic and hydraulic analysis presented in Appendix C, the combined spillways will pass 12 percent of the Probable Maximum Flood. The Probable Maximum Flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The recommended guidelines from the Department of the Army, Office of the Chief of Engineers, require that this structure (small size with high downstream hazard potential) pass 50 percent to 100 percent of the PMF, without overtopping. Considering the height of dam (14 ft), the maximum storage capacity (101 ac-ft), and the presence of the embankment and box culvert (U. S. Highway 66), 100 percent of the PMF has been determined to be the appropriate spillway design flood. The spillways will not pass a 10 percent probability flood without overtopping the dam.

Application of the probable maximum precipitation (PMP), minus losses, resulted in a flood hydrograph peak inflow of 17,000 cfs. For 50 percent of the PMP, the peak inflow was 8,500 cfs.

The routing of the PMF through the spillways and dam indicates that the dam will be overtopped by 2.7 ft at elevation 959.0. The duration of the overtopping will be 7.5 hours, and the maximum outflow will be 17,000 cfs. The maximum discharge capacity of the spillways is 2,020 cfs. The routing of 50 percent of the PMF indicates that the dam will be overtopped by 1.7 ft at elevation 958.0. The maximum outflow will be 8,500 cfs, and the duration of overtopping will be 6.0 hours. Overtopping of an earthen embankment could cause serious erosion and could possibly lead to failure of the structure.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY:

A. Visual Observations:

Observed features which could adversely affect the structural stability of this dam are discussed in Sections 3.1B and 3.2.

B. Design and Construction Data:

No design and construction data for the dam were available.

Seepage and stability analyses comparable to the requirements of the guidelines were not available, which constitutes a deficiency which should be rectified.

C. Operating Records.

No operating records have been obtained.

D. Post-Construction Changes:

There have been no reported post-construction changes.

E. Seismic Stability:

The structure is located in seismic zone 2. An earthquake of this magnitude would not generally be expected to cause severe structural damage to a well constructed earth dam of this size. However, it is recommended that the prescribed seismic loading for this zone be applied in stability analyses performed for this dam.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT.

This Phase I inspection and evaluation should not be considered as being comprehensive since the scope of work contracted for is far less detailed than would be required for an in-depth evaluation of dams. Latent deficiencies, which might be detected by a totally comprehensive investigation, could exist.

A. Safety:

The embankment is generally in less than satisfactory condition. Several items were noted during the visual inspection which should be investigated further, corrected, or controlled. These items are: (1) erosional area on upstream embankment at Station 13 + 00; (2) erosional area on downstream toe at the curve of the embankment near Station 8 + 00; (3) numerous trees (4 to 24 in. diameter) on the embankment slopes; (4) animal burrows on the upstream slope between Station 9 + 00 and 13 + 00; and (5) erosion under and at the outlet of the concrete spillway.

Another deficiency was the lack of seepage and stability analyses records.

The dam will be overtopped by flows in excess of 12 percent of the Probable Maximum Flood. Overtopping of an earthen embankment could cause serious erosion and could possibly lead to failure of the structure.

B. Adequacy of Information:

The conclusions in this report were based on the performance history as related by others and visual observation of external conditions. The inspection team considers that these data are sufficient to support the conclusions herein. Seepage and stability analyses comparable to the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.

C. Urgency:

The remedial measures recommended in paragraph 7.2 should be accomplished in the near future. If the deficiencies listed in paragraph A are not corrected, and if good maintenance is not provided, the embankment condition will continue to deteriorate and possibly could become serious in the future. The items recommended in paragraph 7.2A should be pursued without delay.

D. Necessity for Additional Inspection:

Based on the result of the Phase I inspection, no additional inspection is recommended.

E. Seismic Stability:

The structure is located in seismic zone 2. An earthquake of this magnitude would not generally be expected to cause severe structural damage to a well constructed earth dam of this size. However, it is recommended that the prescribed seismic loading for this zone be applied in any stability analyses performed for this dam.

7.2 REMEDIAL MEASURES:

The following remedial measures and maintenance procedures are recommended. All remedial measures should be performed under the guidance of a professional engineer experienced in the design and construction of dams.

A. Alternatives:

(1) Spillway size and/or height of dam should be increased to pass 100 percent of the PMF. In either case, the spillway should be protected to prevent erosion.

B. O & M Procedures:

(1) Seepage and stability analyses comparable to the requirements of the recommended guidelines should be performed by an engineer experienced in the construction of dams.

(2) Brush and tree growth should be removed from the dam. This should be done under the guidance of a professional engineer experienced in the design and construction of dams. Indiscriminate clearing methods could jeopardize the safety of the dam.

(3) The erosional areas on the embankment should be repaired and seeded.

(4) The erosional areas beneath and near the concrete spillway should be repaired and maintained.

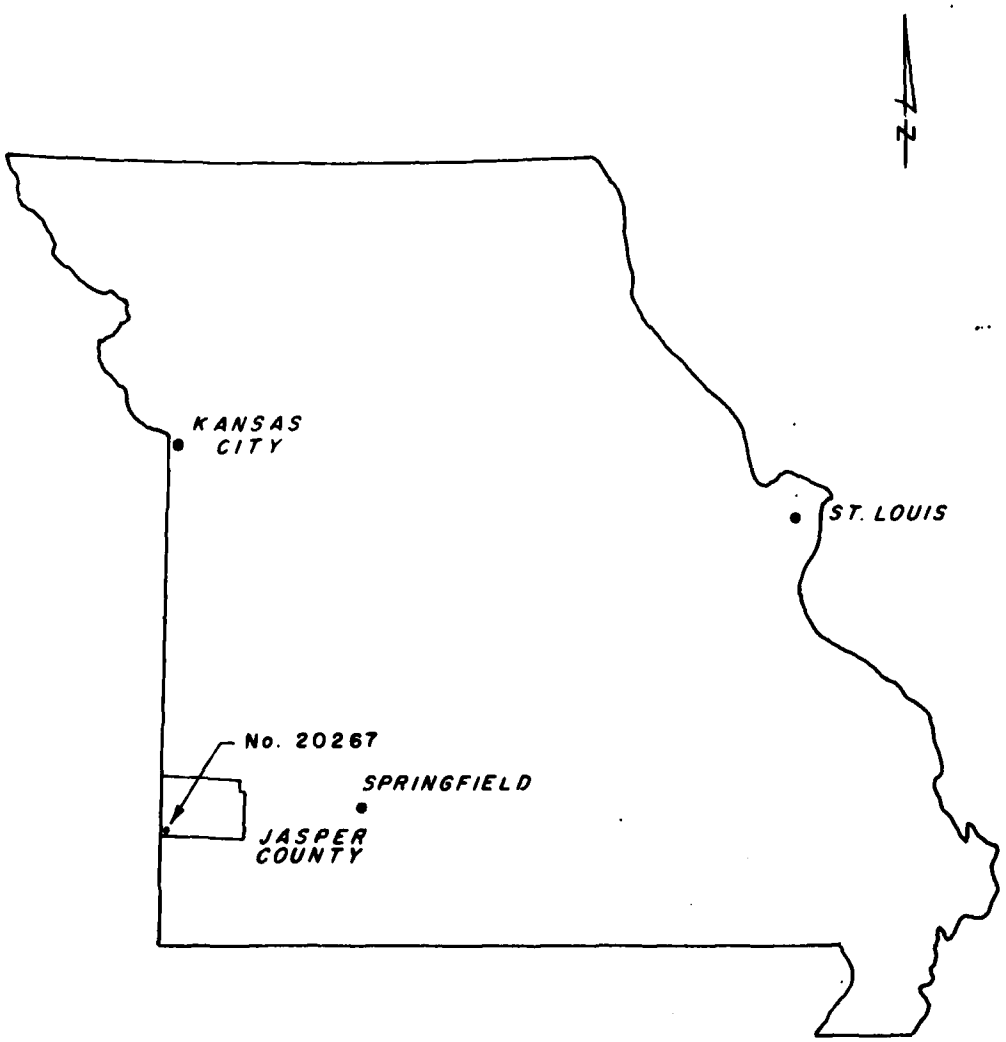
(5) Wave protection should be provided for the upstream face of the dam.

(6) The emergency spillway channel should be lined to prevent spillway releases from eroding the adjacent embankment.

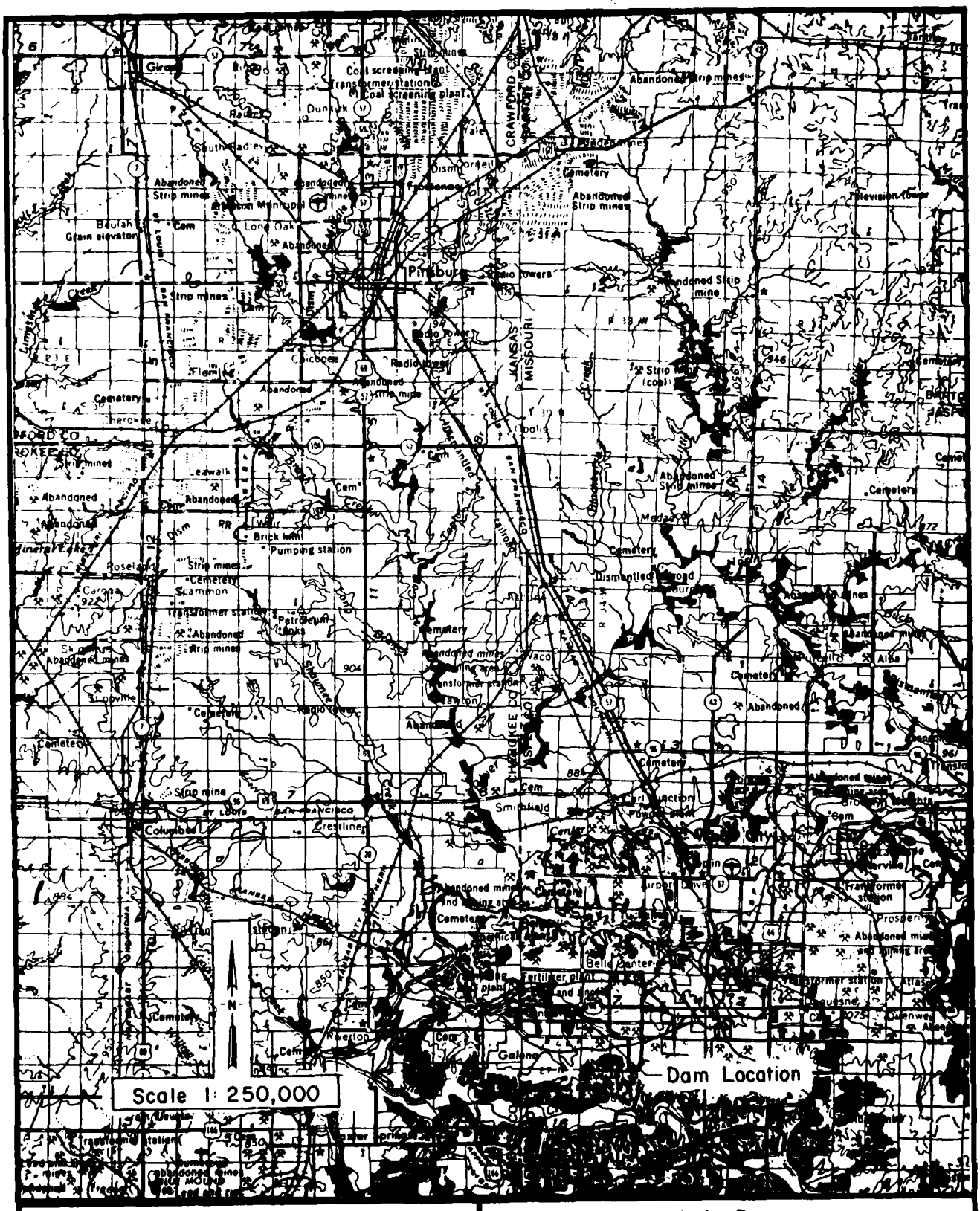
(7) A detailed inspection of the dam should be made periodically by an engineer experienced in the design and construction of dams.

APPENDIX A

Dam Location and Plans



LOCATION MAP



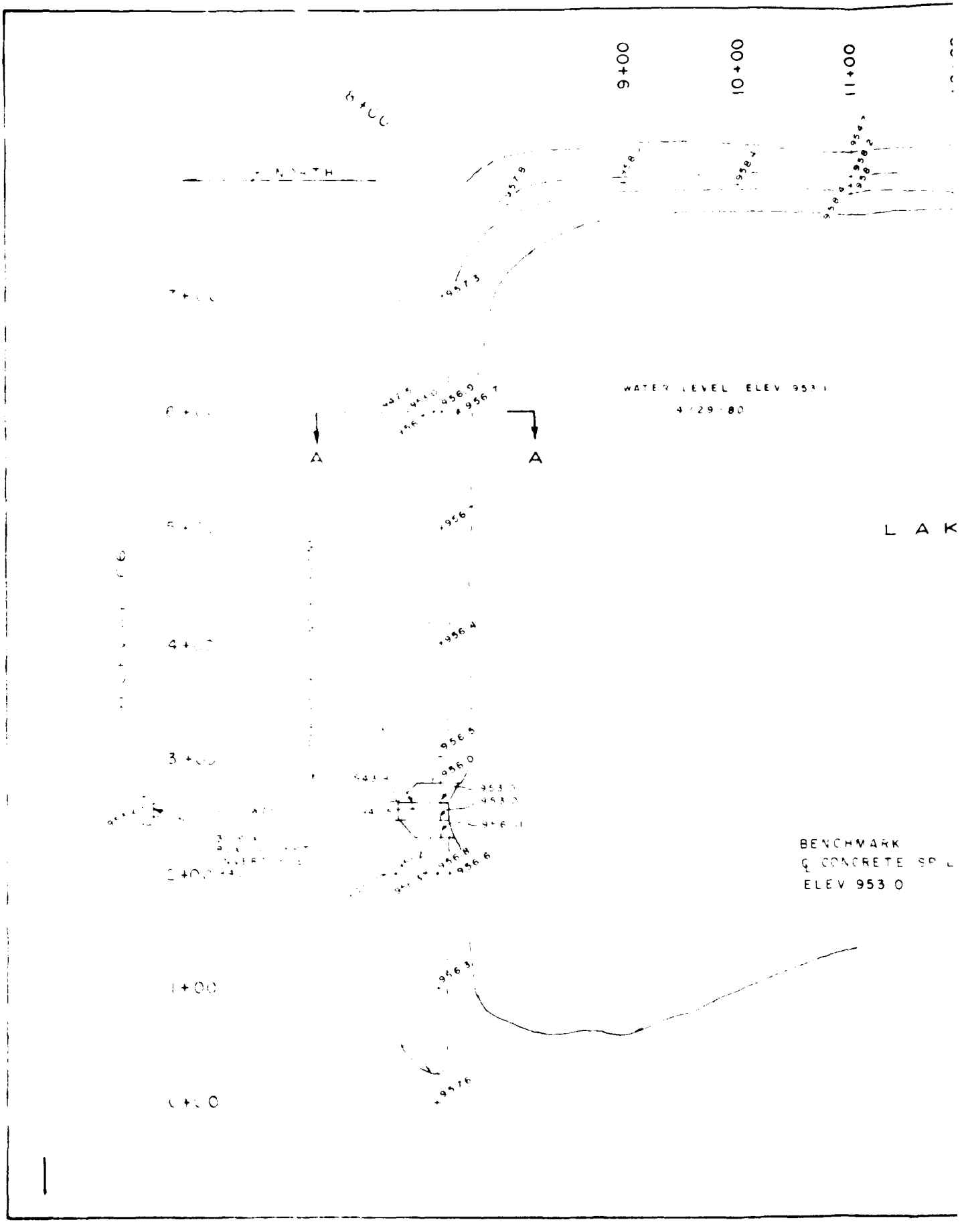
VICINITY MAP

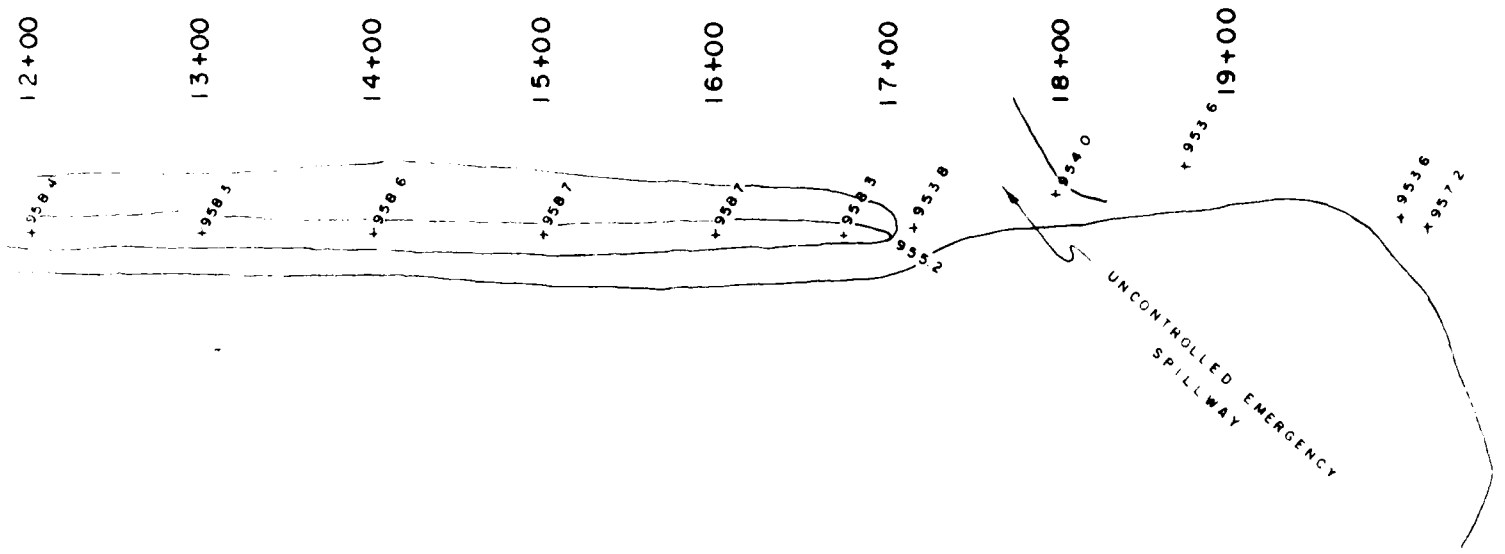
HANSON ENGINEERS INCORPORATED

SPRINGFIELD, IL • PEORIA, IL • ROCKFORD, IL

Rainey Lake Dam
Jasper, County, Missouri
Mo. I.D. No. 20267

Sheet 2, Appendix A

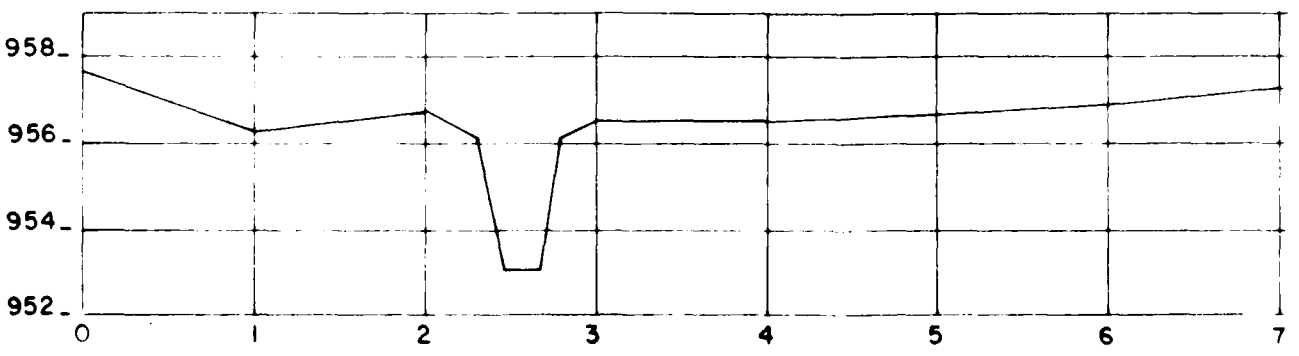

9+00
10+00
11+00
NORTH
A
A
WATER LEVEL ELEV 953.1
4/29/80
LAK
BENCHMARK
ELEV 953.0



L A K E

PLAN VIEW
SCALE 1"=100'

SPILLWAY



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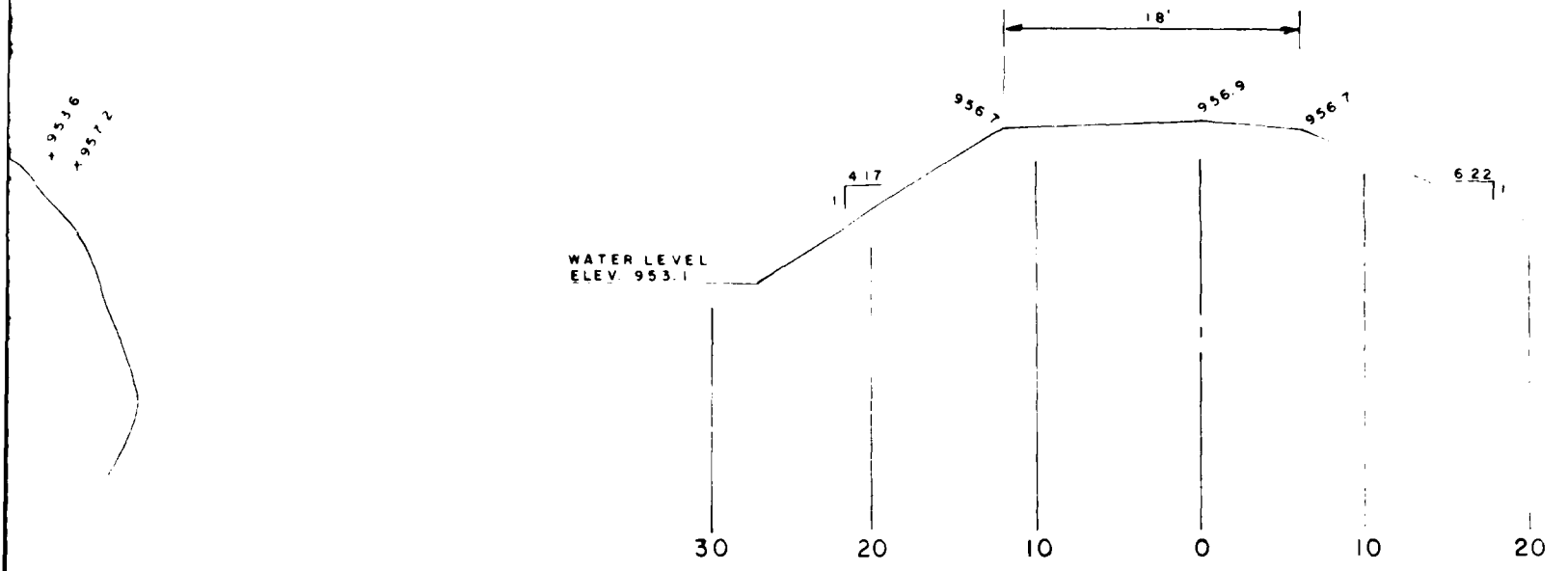
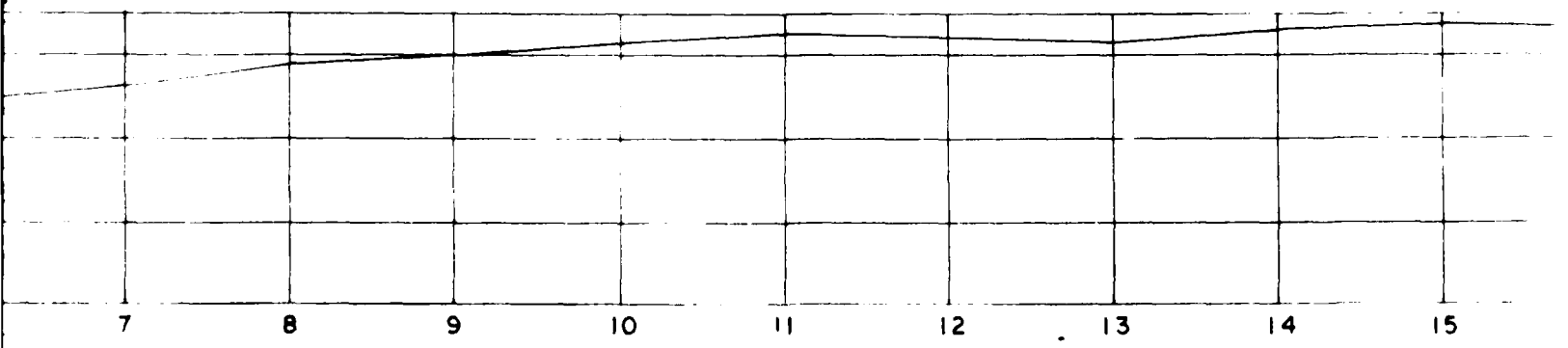
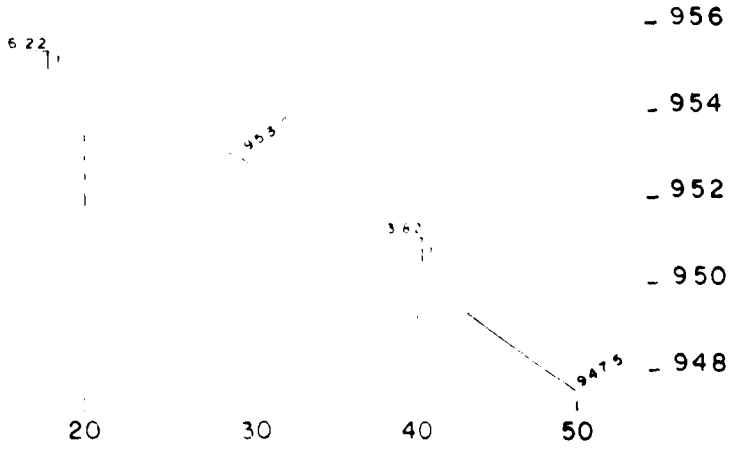


SECTION A-A STA 6+00

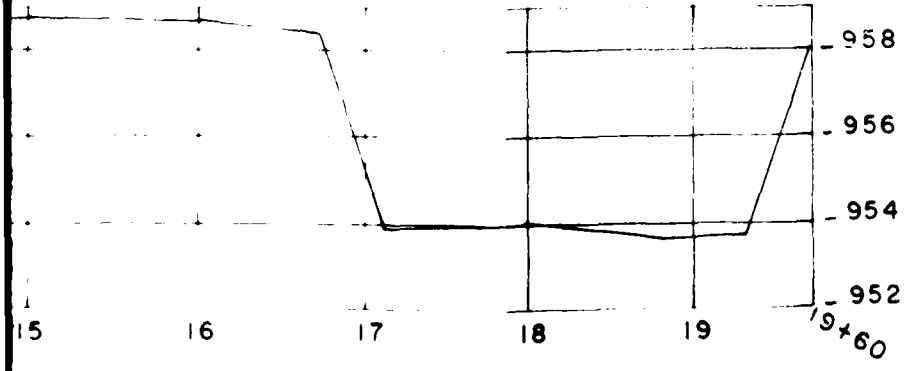


PROFILE

3



6+00



SHEET 3 APPENDIX A

[redacted]

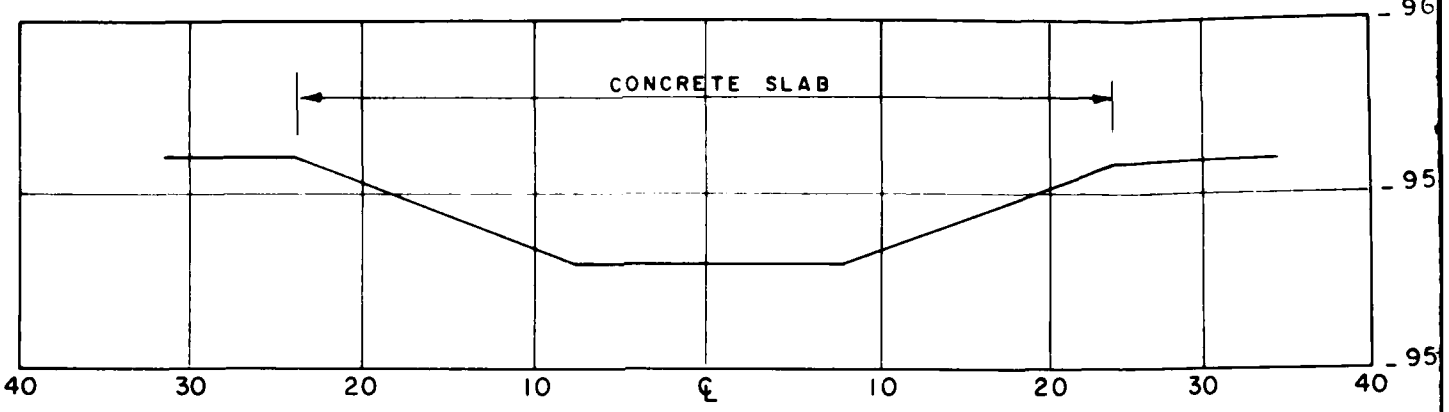
RAINEY LAKE DAM

MO No. 20267

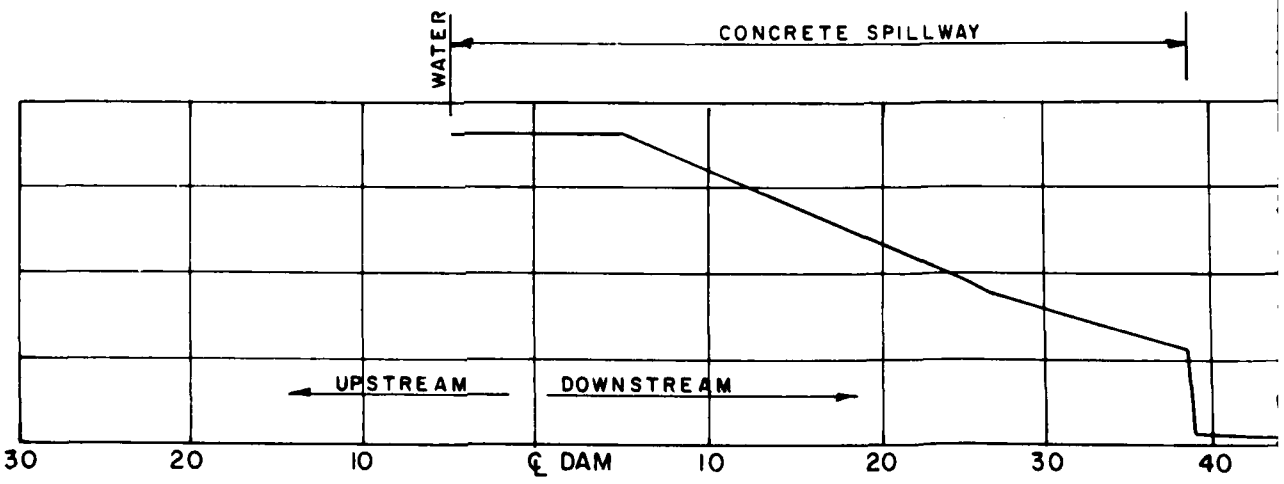
PLAN & PROFILE

JASPER COUNTY, MO.

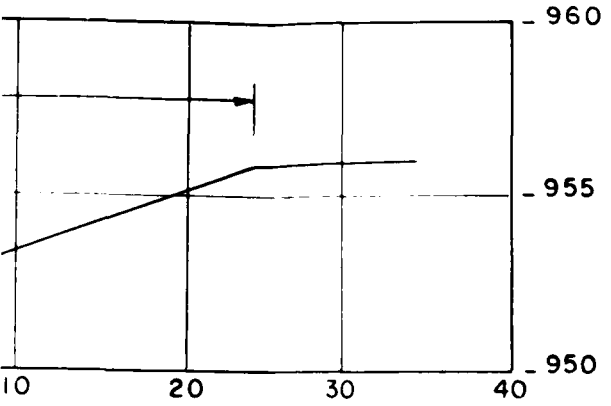
4



SPILLWAY SECTION



SPILLWAY PROFILE



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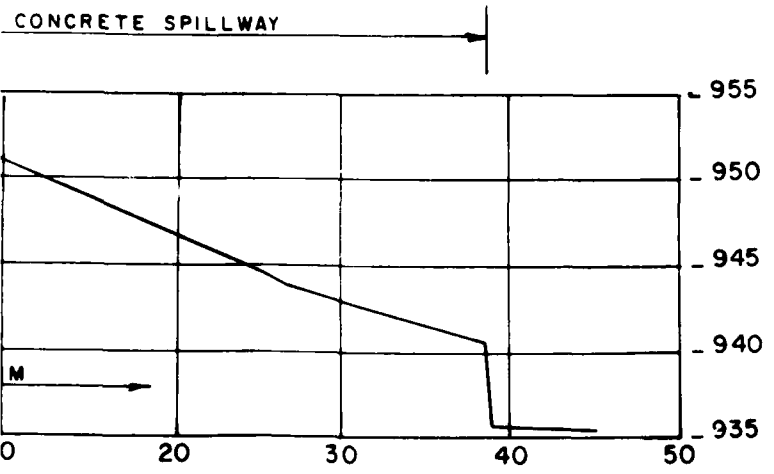


Y PROFILE

2

SHEET 3A APPENDIX A

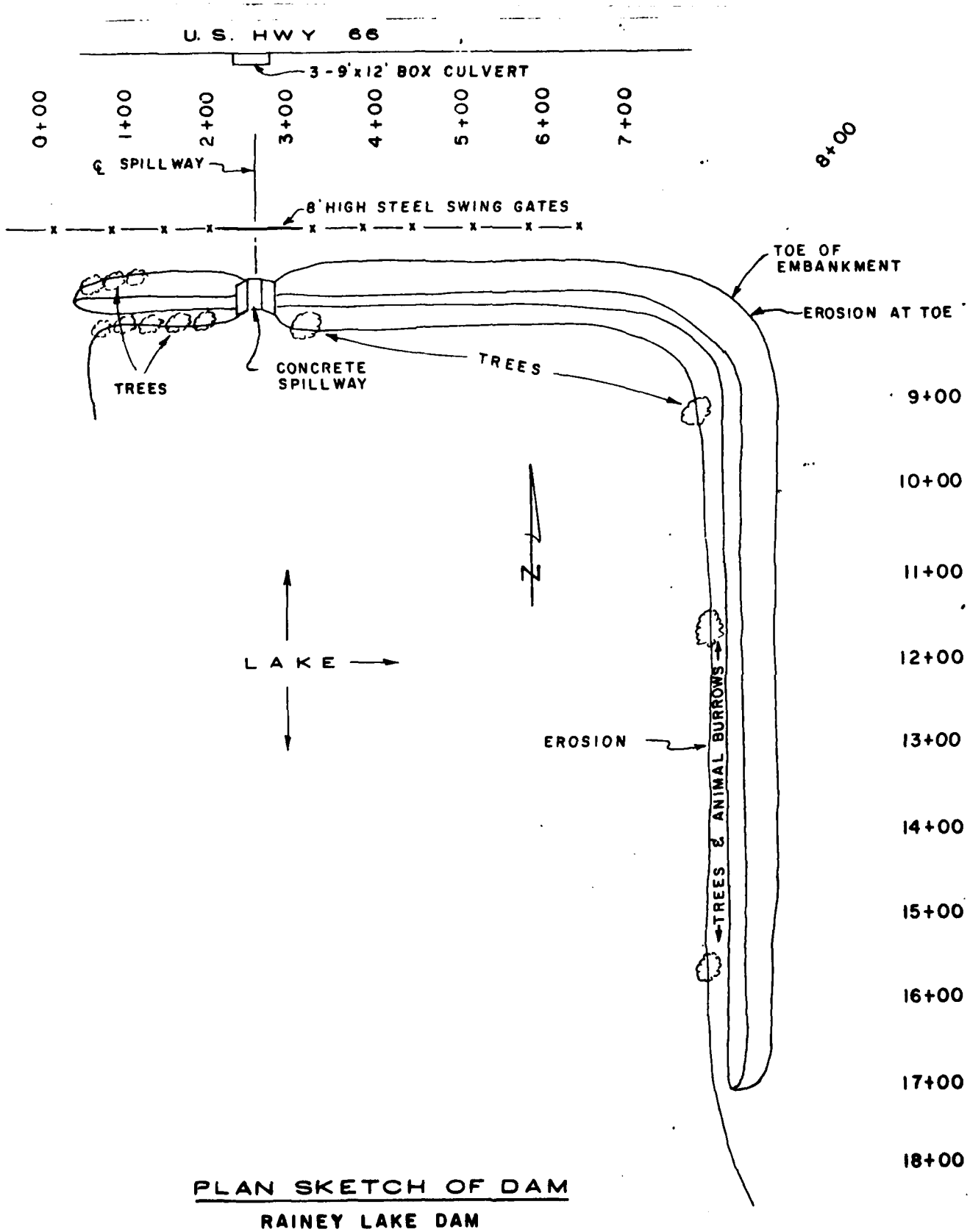
ANDERSON ENGINEERING, INC.
730 NORTH BENTON AVENUE
SPRINGFIELD, MISSOURI 65802

RAINEY LAKE DAM

MO. No 20267

SPILLWAY
SECTION & PROFILE

JASPER COUNTY, MO.

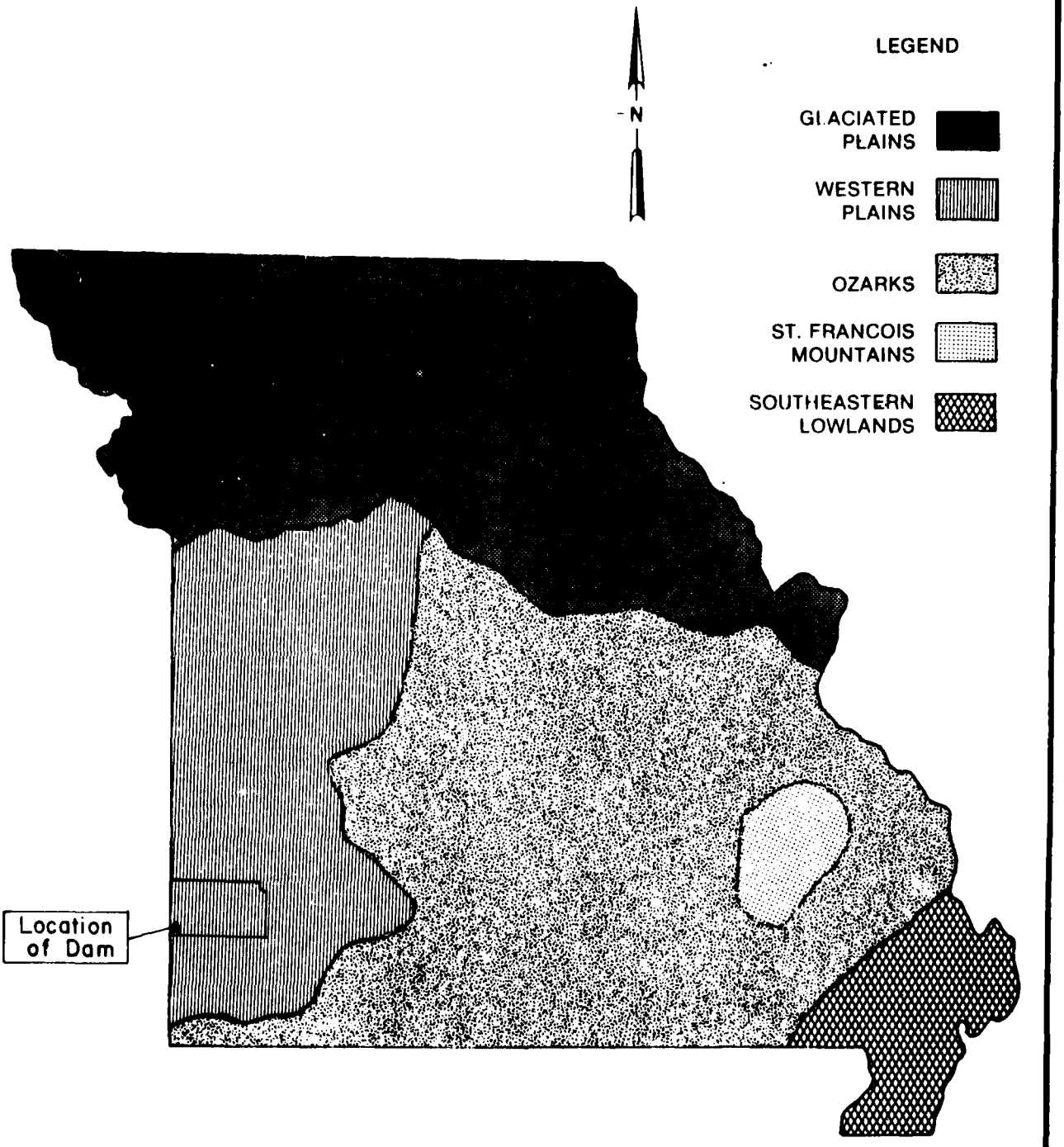


PLAN SKETCH OF DAM

RAINEY LAKE DAM
MO. No. 20267

APPENDIX B

Geology and Soils



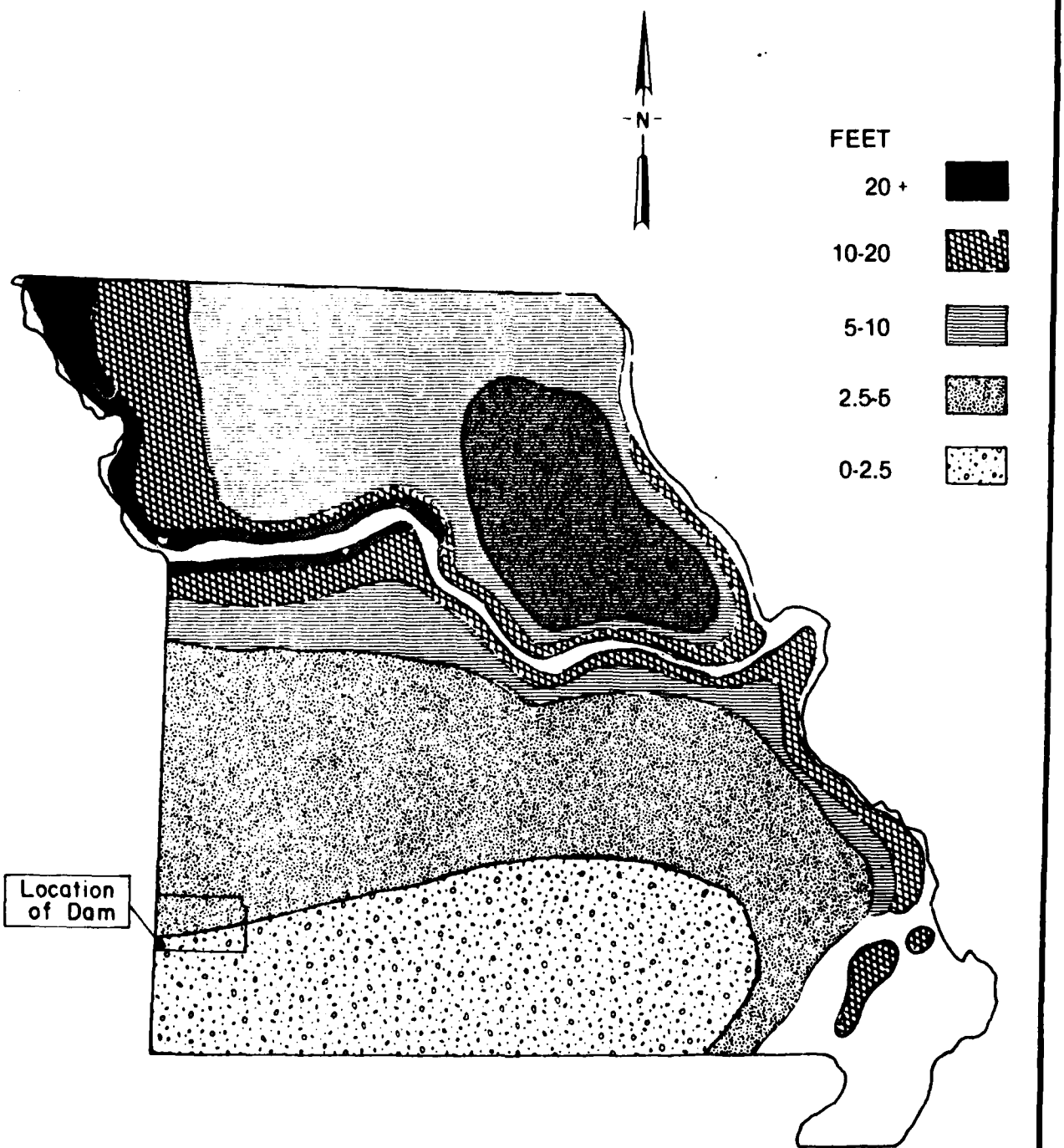
MAJOR GEOLOGIC REGIONS OF MISSOURI

HANSON ENGINEERS

SPRINGFIELD, IL • PEORIA, IL • ROCKFORD, IL

Rainey Lake Dam
Jasper County, Missouri
Mo. I.D. No. 20267

SHEET 1, APPENDIX B



THICKNESS OF LOESSIAL DEPOSITS

HANSON ENGINEERS INCORPORATED

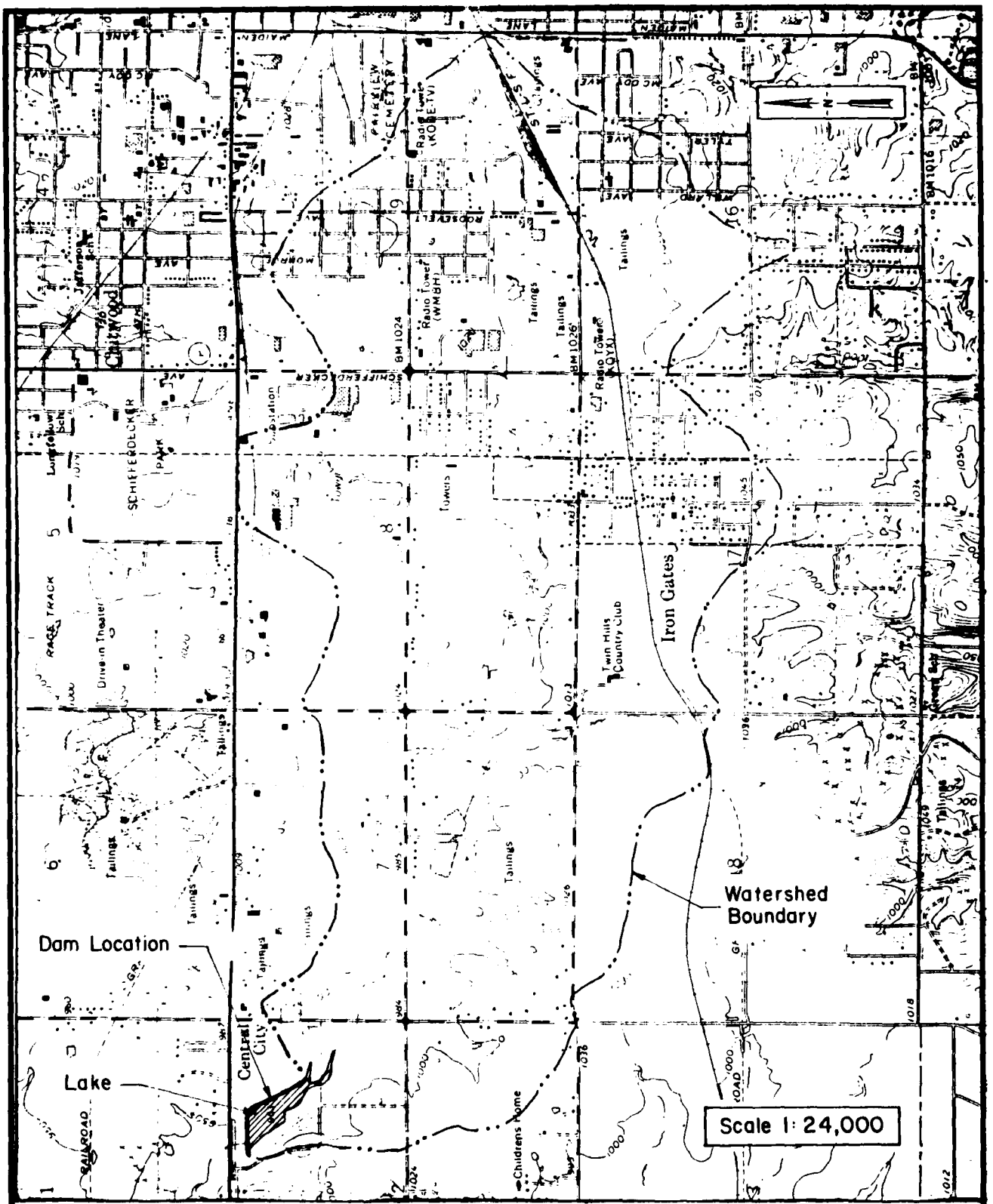
SPRINGFIELD, IL • PEORIA, IL • ROCKFORD, IL

Rainey Lake Dam
Jasper County, Missouri
Mo. I.D. No. 20267

SHEET 2, APPENDIX B

APPENDIX C

Overtopping Analysis



LAKE AND WATERSHED MAP

HANSON ENGINEERS INCORPORATED

SPRINGFIELD, IL • PEORIA, IL • ROCKFORD, IL

Rainey Lake Dam
Jasper, County, Missouri
Mo. I.D. No. 20267

Sheet 1, Appendix C

APPENDIX C

HYDROLOGIC AND HYDRAULIC ANALYSIS

To determine the overtopping potential, flood routings were performed by applying the Probable Maximum Precipitation (PMP) to a synthetic unit hydrograph to develop the inflow hydrograph. The inflow hydrograph was then routed through the reservoir and spillway. The overtopping analysis was accomplished using the systemized computer program HEC-1 (Dam Safety Version), July 1978, prepared by the Hydrologic Engineering Center, U.S. Army Corps of Engineers, Davis, California.

The PMP was determined from regional charts prepared by the National Weather Service in "Hydrometeorological Report No. 33." Reduction factors were not applied. The rainfall distribution for the 48-hour PMP storm duration was assumed according to the procedures outlined in EM 1110-2-1411 (SPD Determination). Also, the 1 percent and the 10 percent chance probability floods were routed through the reservoir and spillways. Joplin rainfall distribution (15 min. interval - 48 hours duration), as provided by the St. Louis District, Corps of Engineers, was used in this case.

The synthetic unit hydrograph for the watershed was developed by the computer program using the SCS method. The parameters for the unit hydrograph are shown in Table 1 (Sheet 4, Appendix C).

The SCS curve number (CN) method was used in computing the infiltration losses for rainfall-runoff relationship. The CN values used, and the result from the computer output, are shown in Table 2 (Sheet 5, Appendix C).

The reservoir routing was accomplished by using the Modified Puls Method. The hydraulic capacity of the spillways was used as an outlet control in the routing. The hydraulic capacity of the spillway and the storage capacity of the reservoir were defined by the elevation-surface area--storage-discharge relationships shown in Table 3 (Sheet 5, Appendix C).

There is a road embankment and a culvert about 200 ft downstream from the primary spillway. We believe that the road embankment and the culvert will restrict the flows for floods equal and bigger than the 1 percent probability flood and will control the discharges from the spillways. This effect was not considered in the routings analysis.

The rating curve for the spillways are shown on Table 4 Sheet 6, Appendix C. Critical flow over a broad-crested weir was assumed for the primary spillway and open channel flow for the emergency spillway.

The result of the routings analysis indicates that the 10 percent probability flood will overtop the dam.

The flow over the crest of the dam during overtopping was determined using the non-level dam option ($L and $V cards) of the HEC-1 program. The program assumes critical flow over a broad-crested weir.

A summary of the routing analysis for different ratios of the PMF is shown on Table 5 (Sheet 7, Appendix C).

The computer input data, a summary of the output data, and a plot of the inflow-outflow hydrograph for the PMF are presented on Sheets 8, 9 and 10 of Appendix C.

TABLE 1

SYNTHETIC UNIT HYDROGRAPH

Parameters:

Drainage Area (A)	3.34 sq. miles
Length of Watercourse (L)	3.3 miles
Difference in elevation (H)	97 feet
Time of concentration (Tc)	1.77 hours
Lag Time (Lg)	1.06 hours
Time to peak (Tp)	1.19 hours
Peak Discharge (Qp)	1364 c.f.s.
Duration (D)	15 min.

Time (Min.)(*)	Discharge (cfs)(*)
0	0
15	150
30	470
45	971
60	1303
75	1355
90	1204
105	958
120	643
135	451
150	327
165	233
180	164
195	117
225	58
255	29
285	15
315	5

(*) From the computer output

FORMULA USED:

$$Tc = \left(\frac{11.9\ L^3}{H}\right)^{0.385}$$

$$Lg = 0.6\ Tc$$

$$Tp = \frac{D}{2} + Lg$$

$$Qp = \frac{484\ A.Q}{Tp}$$ A = Excess Runoff = 1 inch

TABLE 2

RAINFALL-RUNOFF VALUES

Selected Storm Event	Storm Duration (Hours)	Rainfall (Inches)	Runoff (Inches)	Loss (Inches)
PMP	48	37.80	36.87	0.93
1% Prob. Flood	48	9.68	7.71	1.97
10% Prob. Flood	48	6.64	4.81	1.82

Additional Data:

1) Soil Conservation Service Soil Group D
2) Soil Conservation Service Runoff Curve CN = 91 (AMC III) for the PMF
3) Soil Conservation Service Runoff Curve CN = 80 (AMC II) for the 1 percent probability flood
4) Percentage of Drainage Basin Impervious 20 percent

TABLE 3

ELEVATION, SURFACE AREA, STORAGE AND DISCHARGE RELATIONSHIPS

Elevation (feet-MSL)	Lake Surface Area (acres)	Lake Storage (acre-ft)	Spillway Discharge (cfs)
943.0	0	0	-
*953.0	12	50	0
954.0	14	63	58
**956.3	19	101	2020
960.0	26	183	10680

*Primary spillway crest elevation
**Top of dam elevation

The above relationships were developed from the Joplin West, MO.-KANS. 7.5 minute quadrangle map and the field measurements.

TABLE 4

SPILLWAYS RATING CURVE

Reservoir Elevation	Primary Spillway (c.f.s.)	Emergency Spillway (c.f.s.)	Total Discharge (c.f.s.)
953.0	0	-	0
954.0	58	0	58
954.5	117	106	223
955.0	197	354	551
955.5	299	708	1007
956.0	424	1160	1584
*956.3	520	1500	2020
957.0	750	2440	3190
958.0	1186	4040	5226
959.0	1740	6000	7740
960.0	2420	8260	10680

*Top of Dam Elevation

METHOD USED:

1) Primary Spillway: Assuming critical flow on a trapezoidal broad-crested weir.

$Q = C_2.b.H_m^{1.5}$

Q = Discharge in c.f.s.

C_2 = Coefficient from Table 8-7, Page 8-58 "Handbook of Hydraulics" by King and Brater (Fifth Edition)

b = Bottom width of channel (weir) = 15 ft

Hm = Energy head in ft

2) Emergency Spillway: Assuming open channel flow

Using charts from "UD Method of Reservoir Flood Routing," S.C.S. Technical Release No. 35, February 1967.

TABLE 5

RESULTS OF FLOOD ROUTINGS

Ratio of PMF	Peak Inflow (CFS)	Peak Lake Elevation (ft.-MSL)	Total Storage (AC.-FT.)	Peak Outflow (CFS)	Depth (ft.) Over Top of Dam
-	0	*953.0	50	0	-
0.10	1701	956.1	97	1682	-
0.12	2042	**956.3	101	2020	0
0.15	2552	956.6	107	2528	0.3
0.20	3403	956.9	115	3403	0.6
0.25	4253	957.2	120	4253	0.9
0.30	5104	957.4	125	5104	1.1
0.40	6806	957.7	132	6806	1.4
0.50	8507	958.0	139	8507	1.7
0.75	12760	958.6	152	12760	2.3
1.00	17014	959.0	161	17014	2.7

The percentage of the PMF that will reach the top of the dam is 12 percent.

*Primary spillway crest elevation
**Top of dam elevation

```
A       OVERTOPPING ANALYSIS FOR RAINEY LAKE DAM ( # 6 )
A       STATE ID NO. 20267  COUNTY NAME : JASPER
A       HANSON ENGINEERS INC. DAM SAFETY INSPECTION JOB # 80S3001
B    192              15
B1     5
J      1       9       1
J1   .10     .15     .20     .25     .30     .40     .50     .75     1.0
K      0       1                               3       1
K1      INFLOW HYDROGRAPH COMPUTATION **
M      1       2    3.34            3.34       1                       1
P      0    27.0     102     120     130     140
T                                                   -1     -91             0.20
U2  1.77    1.06
X      0    -.1       2
K      1       2                       0       4       1
K1      RESERVOIR ROUTING BY MODIFIED PULS AT DAM SITE **
Y                                       1       1
Y1     1                                                50      -1
Y4   953     954   954.5     955   955.5     956   956.3     957     958     959
Y4   960
Y5     0      58     223     551    1007    1584    2020    3190    5226    7740
Y5 10680
$S     0      50     101     183
$E   943     953   956.3     960
$$   953
$D 956.3
$L    22     200     364     446     510     640     772     960    1290    1700
$V 956.3   956.5   956.7   956.8   956.9   957.3   957.8   958.2   958.4   958.7
K     99
```

PMF Ratios
Input Data

********** ********** ********** ********** **********

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

				RATIOS APPLIED TO FLOWS								
OPERATION	STATION	AREA	PLAN	RATIO 1	RATIO 2	RATIO 3	RATIO 4	RATIO 5	RATIO 6	RATIO 7	RATIO 8	RATIO 9
				0.10	0.15	0.20	0.25	0.30	0.40	0.50	0.75	1.00
HYDROGRAPH AT	1	3.34	1	1701.	2552.	3403.	4253.	5104.	6806.	8507.	12760.	17014.
	(	8.65)	(	48.18)(	72.27)(	96.36)(	120.44)(	144.53)(	192.71)(	240.89)(	361.33)(	481.78)
ROUTED TO	2	3.34	1	1682.	2528.	3406.	4265.	5119.	6826.	8535.	12788.	17033.
	(	8.65)	(	47.64)(	71.59)(	96.46)(	120.77)(	144.94)(	193.29)(	241.69)(	362.12)(	482.33)

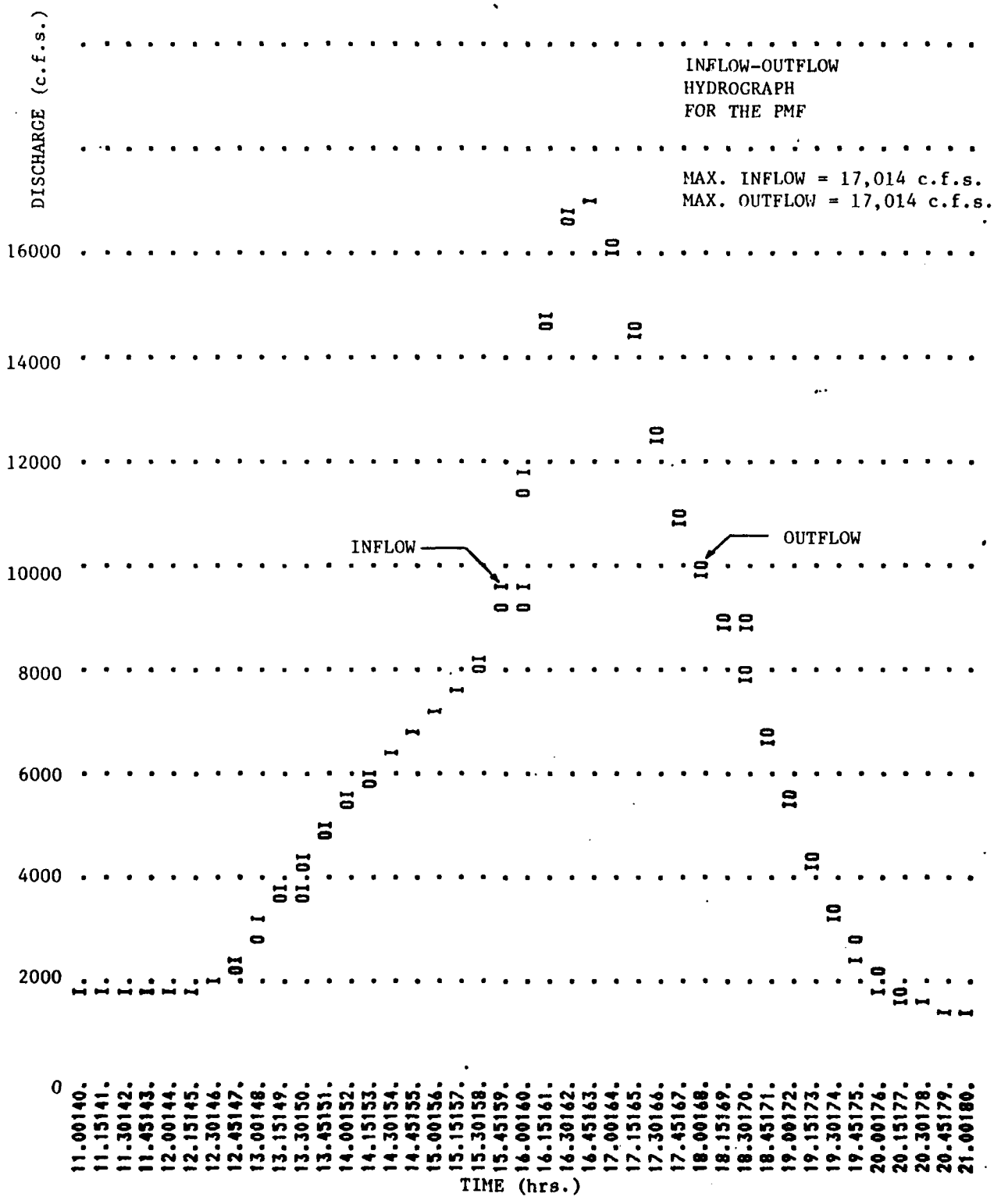
SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	953.00	953.00	956.30
STORAGE	50.	50.	101.
OUTFLOW	0.	0.	2020.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
0.10	956.07	0.00	97.	1682.	0.00	40.75	0.00
0.15	956.57	0.27	107.	2528.	1.25	40.75	0.00
0.20	956.92	0.62	115.	3406.	2.25	40.75	0.00
0.25	957.16	0.86	120.	4265.	3.00	40.75	0.00
0.30	957.36	1.07	125.	5119.	4.00	40.75	0.00
0.40	957.72	1.42	132.	6826.	5.25	40.75	0.00
0.50	958.02	1.72	139.	8535.	6.00	40.75	0.00
0.75	958.58	2.28	152.	12788.	7.00	40.75	0.00
1.00	959.00	2.70	161.	17033.	7.50	40.75	0.00

PMF Ratios
Output Data


INFLOW-OUTFLOW
HYDROGRAPH
FOR THE PMF
MAX. INFLOW = 17,014 c.f.s.
MAX. OUTFLOW = 17,014 c.f.s.
DISCHARGE (c.f.s.)
16000
14000
12000
10000
8000
6000
4000
2000
0
INFLOW
OUTFLOW
11.00140.
11.15141.
11.30142.
11.45143.
12.00144.
12.15145.
12.30146.
12.45147.
13.00148.
13.15149.
13.30150.
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TIME (hrs.)

APPENDIX D

Photographs

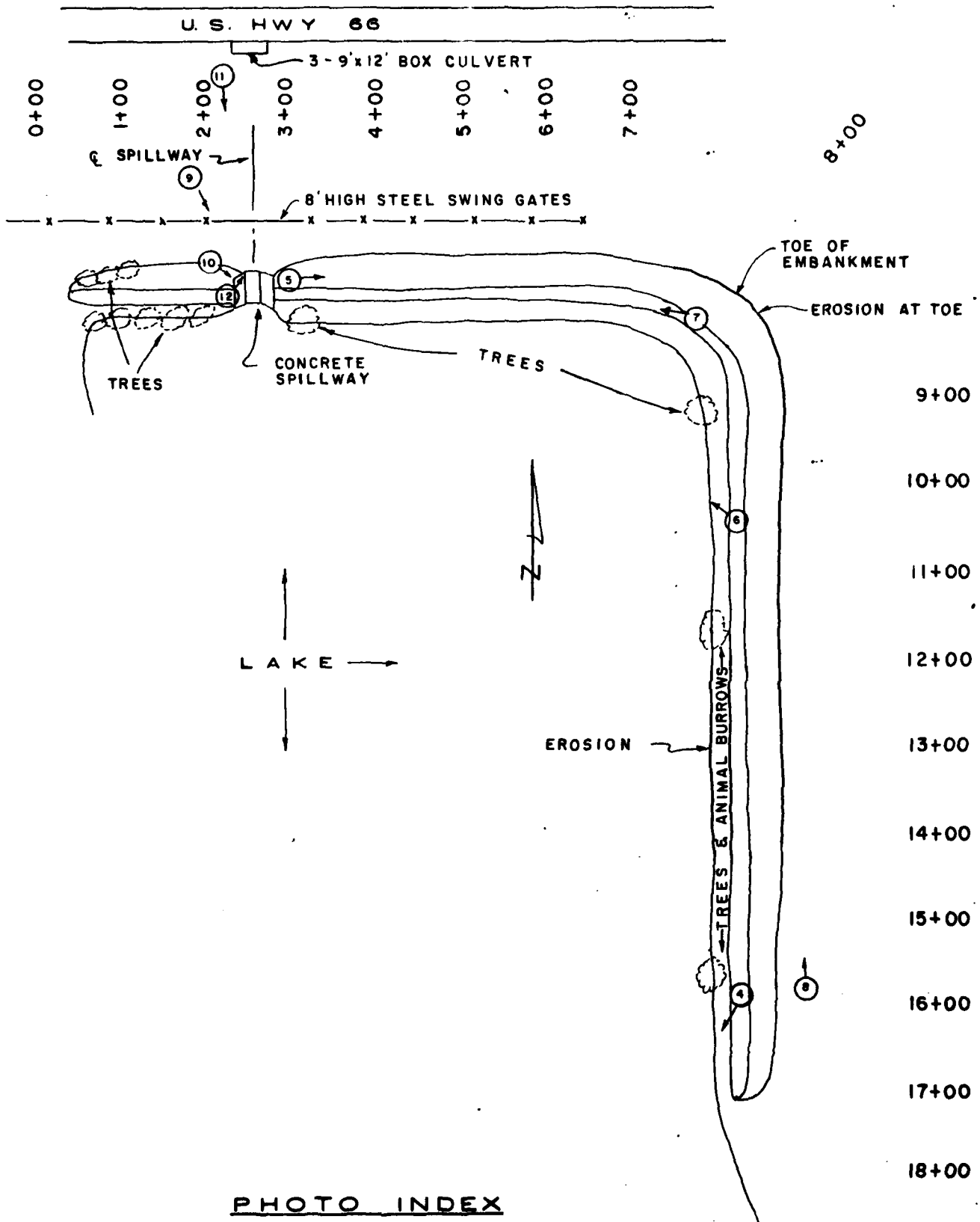


PHOTO INDEX

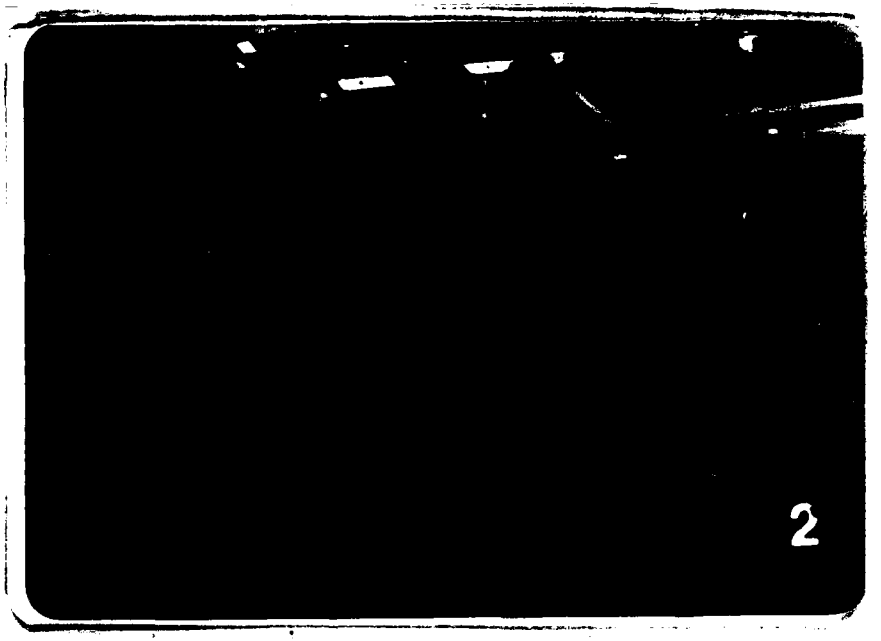
RAINEY LAKE DAM

MO. No. 20267

LIST OF PHOTOGRAPHS

Photo No.	Description
1	Aerial View of Lake and Dam
2	Aerial View of Lake and Dam
3	Aerial View of Primary Spillway and Downstream Channel
4	View of Lake and Reservoir Area (Looking South)
5	Downstream Slope (Looking East)
6	Upstream Slope (Looking Northwest)
7	Crest of Embankment (Looking West)
8	Embankment and Emergency Spillway (Looking North)
9	Primary Spillway (Looking South)
10	Erosional Area Beneath Spillway Slab
11	Primary Spillway and Swing Gates (Looking South)
12	View from Primary Spillway (Looking North)


1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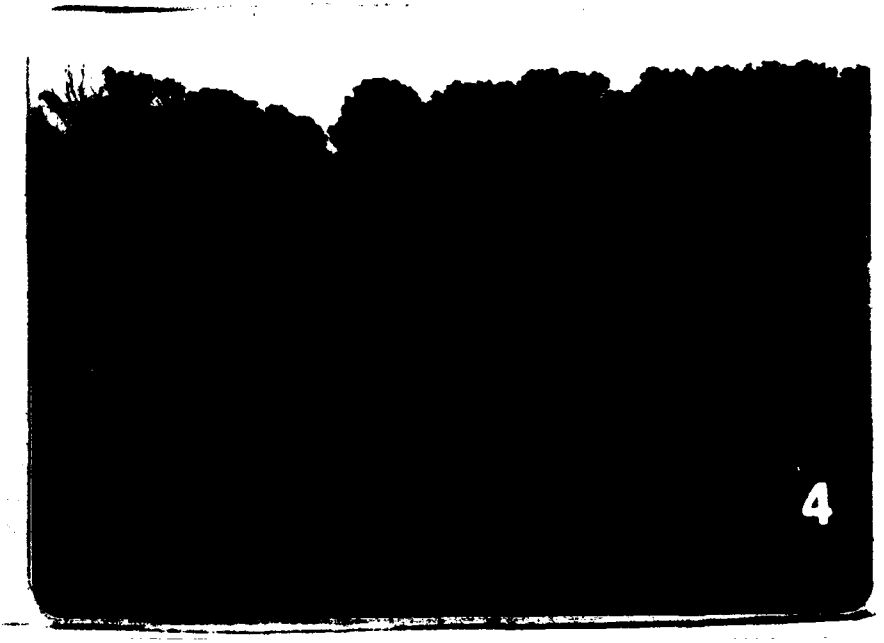
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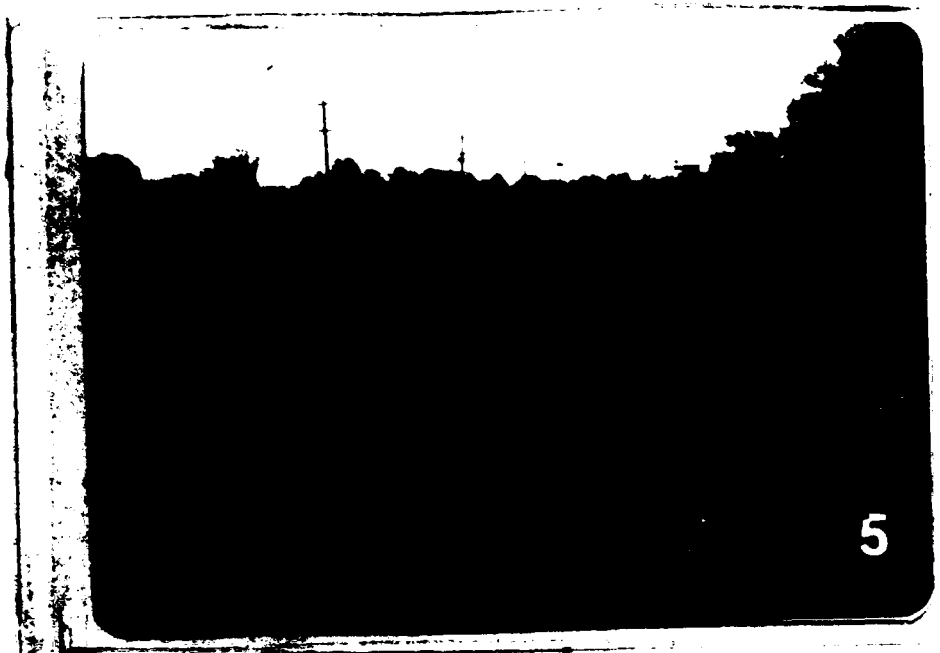
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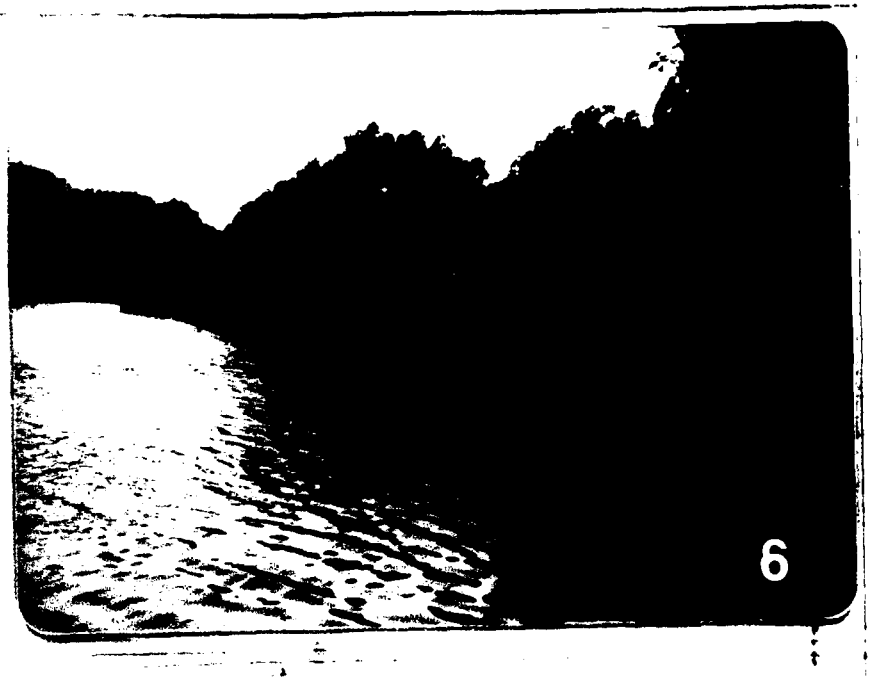
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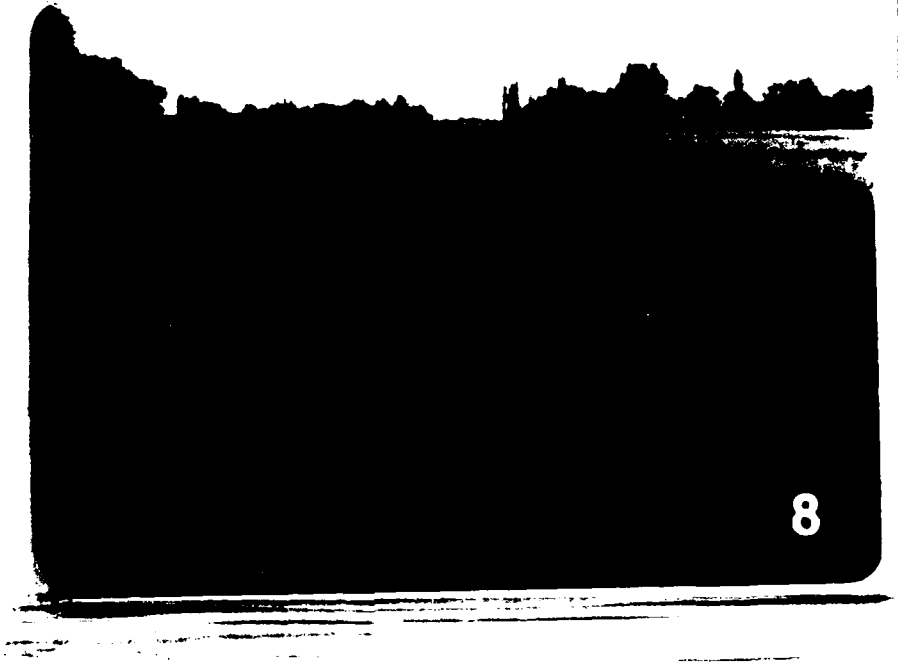
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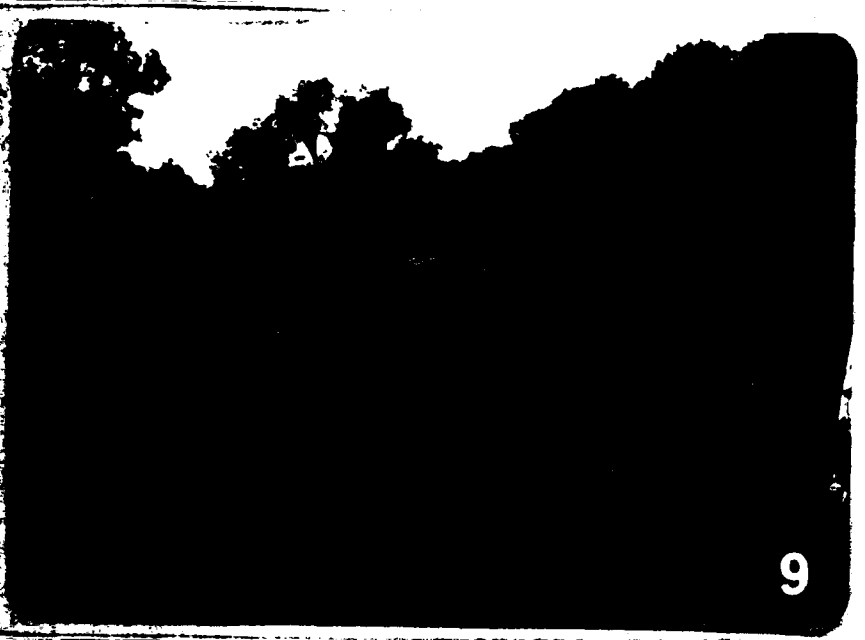
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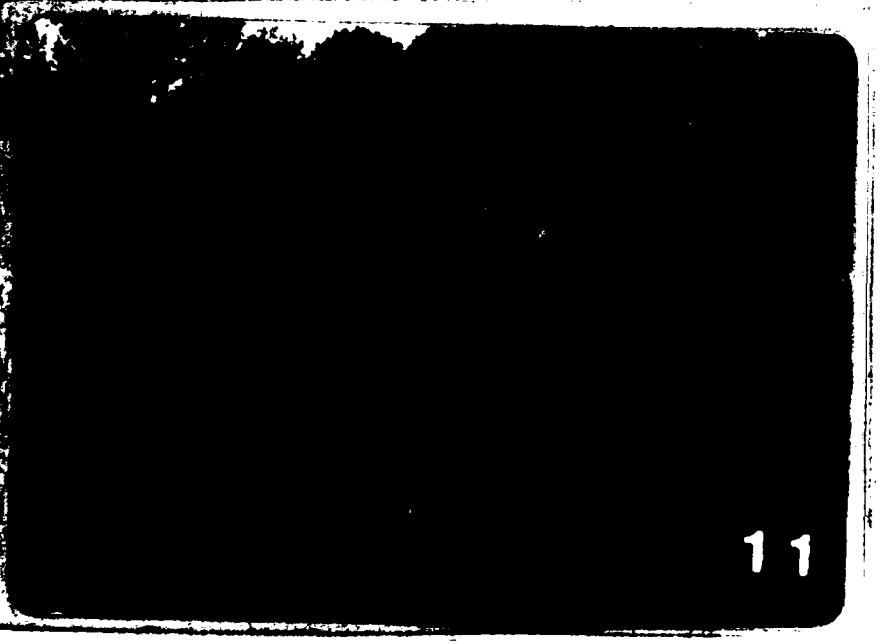
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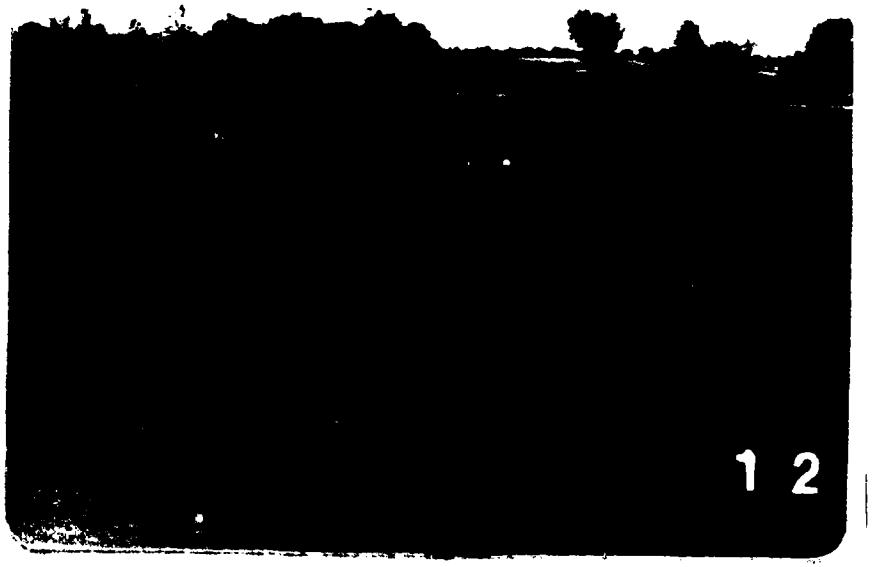
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